OPTIMIZATION ON ACRYLIC ACID PLANT BY USING ASPEN PLUS

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LIST OF ABBREVIATIONS

PROPY-01	–	Propylene
NITRO-01	–	Nitrogen
OXYGE-01	–	Oxygen
CARBO-01	–	Carbon Dioxide
WATER	–	Water
ACETI-01	–	Acetic Acid
ACRYL-01	–	Acrylic Acid
DIISO-01	–	Diisopropyl Ether
PROIN	–	Inlet of Propylene
PROOUT	–	Outlet of Propylene
ACRY	–	Mole Flow of Acrylic Acid
TACRY	–	Total Mole Flow of Acrylic Acid
ACET	–	Mole Flow of Acetic Acid
TACET	–	Total Mole of Acetic Acid
DIPE	–	Diisopropyl Ether
DIISO	–	Mole Flow of Diisopropyl Ether
TDIISO	–	Total Mole Flow of Diisopropyl Ether
TOTAL 1	–	Total Mole Flow of Stream 22
TOTAL 2	–	Total Mole Flow of Stream 21
T	–	Temperature
P	–	Pressure
WAT	–	Water
FS	–	Feed Stages Location
RR	–	Reflux Ratio
RD	–	Re-boiler Heat Duty
DIAM	–	Diameter
LENGTH	–	Length
PD	–	Pressure Drop

TUBE	–	Number of Tube
TEM	–	Temperature
Pres	–	Pressure
CD	–	Condenser Heat Duty
NS	–	Number of Stage
BR	–	Bottom Rate
CT	–	Constant Temperature
CP	–	Constant Pressure
REACRY	–	Recovery of Acrylic Acid
REACET	–	Recovery of Acetic Acid
PUR 1	–	Purity of Acrylic Acid
PUR 2	–	Purity of Acetic Acid

PENGOPTIMUMAN PADA LOJI ASID AKRILIK DENGAN MENGGUNAKAN ASPEN PLUS

ABSTRAK

Pengoptimuman pada reacktor dan pemisah bahagian daripada loji asid akrilik telah diyiasatkan dalam pengajian ini. Untuk mendapatkan kadar pengeluaran yang lebih tinggi dan kualiti yang lebih baik bagi produk asid akrilik, Aspen Plus telah diggunakan untuk mensimulasikan dan mengoptimumkan loji asid akrilik tersebut. Unit operasi yang dilibatkan adalah reacktor system, wap pemulihan system dan pemulihan system cecair. Metodologi penyelidikan ini telah dipisahkan kepada tiga fasa, iaitu, pertama sekali mensimulasikan loji asid akrilik dalam keadaan yang mantap, kedua analisis sensitiviti, dan akhirnya adalah pengoptimuman. Berdasarkan keputusan yang telah dapat, loji asik akrilik telah berjaya mensimulasikan dalam Aspen Plus dan kadar pengeluaran akhir produk adalah diterimakan. Untuk bahagian yang pengoptimuman, suhu optimum reacktor adalah 315℃ untuk mendapatkan hasil maksimum asid akrilik, iaitu 0.77254. Untuk unit dram flash, optimum suhu dan tekanan adalah 25℃ and 4.84atm masing-masing. Untuk menara penyerapan dan cecair-cecair pemerah, optimum kadar aliran air dan pelarut adalah 100kmol/j dan 1350kmol/j masing-masing untuk mendapatkan lebih daripada 99% asid akrilik dan asid asetik. Untuk turus penyulingan kesatu, peringkat suapan lokasi optimum, nisbah refluks dan duti haba dibekalkan adalah nombor 8, 4.44308 dan 180000MJ/j masing-masing untuk memaksimumkan pemulihan asid dan pelarut. Untuk turus penyulingan kedua, peringkat suapan lokasi, nisbah refluks dan duti haba dibekalkan adalah nombor 23, 10.5 dan 3000MJ/j masing-masing untuk mendapatkan kesucian asid akrilik yang paling tinggi. Untuk keputusan keseluruhan, ia mendapati bahawa mengoptimumkan keadaan operasi unit akan mendapatkan produk yang berkualiti dan lebih banyak bahan boleh dipulihkan.

OPTIMIZATION ON ACRYLIC ACID PLANT BY USING ASPEN PLUS

ABSTRACT

In this research of study, optimization of reactor and separators sections on acrylic acid production plant was investigated. In order to obtain higher production rate and maintain desired quality of products, the Aspen Plus simulator is used to simulate and optimize on the acrylic acid plant. The units proceed with optimization consists of reactor system, vapour recovery system (adsorption tower, and flash drum) and liquid recovery system (liquid-liquid extractor, and distillation column). The research methodology as separated into three phases, which are steady state simulation, sensitivity analysis and optimization. Based on the result obtained, the acrylic acid production plant was simulated successfully in Aspen Plus flow sheet and the final production rate of products is acceptable. For the optimization, optimum temperature of reactor is 315℃ in order to obtain the maximum yield of acrylic acid which is 0.77254. For the flash drum unit, optimum temperature and pressure are 25℃ and 4.84atm respectively. For the absorption tower and liquid-liquid extractor, optimum molar flow rate of water and solvent are 100kmol/h and 1350kmol/h respectively in order to recover more than 99% of acrylic and acetic acid. For the distillation column 1, optimum feed stages location, reflux ratio and re-boiler heat duty are number of 8, 4.44308 and 180000MJ/h respectively in order to maximize recovery of acids and solvent. For the distillation column 2, optimum feed stages location, reflux ratio and re-boiler heat duty are number of 23, 10.5 and 3000MJ/h respectively in order to maximize purity of acrylic acid. For overall result, it was found that by optimizing the operating conditions of units, desired quality of products is improved and more materials is recovered.

CHAPTER 1

INTRODUCTION

1.1 Background of the Study

Acrylic acid becomes more important in our daily life due to its wide applications such as its use in the manufacturing of plastic, coating, paper coating, polishes paint formulations, leather finishing, polymers, textile industries and adhesive. Hence, production of acrylic acid is increasing from year to year in order to fulfill the human needs. Due to this reason, amount of production of acrylic acid in the acrylic plant is also increasing. At the same time, acrylic plant must be able to maintain the same desired quality of acrylic acid by optimizing operating conditions in reactor and separation sections.

In the industry, the complicated problems of chemical plant are not always solved by human due to the human errors and time constraints (Bernards & Overney, 2004). There are many types of simulation programs that are used in industry which depends on the application, desired simulation products and the field of industry. Aspen plus is a powerful tool for Chemical Engineering in various fields including oil and gas production, refining, chemical processing, environmental studies, and power generation (Bernards & Overney, 2004). Therefore, Aspen Plus simulator is chosen for this study.

In present work, the acrylic acid production plant is simulated and optimized by using Aspen Plus software. The plant has two major sections which consist of reactor and separation section. In the reactor section, propylene undergoes oxidation reactions to become acrylic and acetic acid. In the separation section, products undergo five separation units in order to obtain the desired products. These five main separation units consist of flash drum, absorption tower, liquid-liquid extractor, and two units of distillation columns. Separation efficiency of each separation unit depends on operation conditions which will directly affect the amount of loss of materials, operating cost, and the desired quality of the final products.

Optimization plays an important role in order to obtain the desired quality of acrylic and acetic acids. Before carrying out the optimization, steady state simulation of the acrylic acid plant must be first simulated. Therefore, reactor and separation sectors can be optimized in order to maximize the profits, reduce energy consumption, get higher processing rates, reduce maintenance cost, and have longer time between shutdowns. The optimization parameters consists of reflux ratio, feed stages location, temperature, pressure, re-boiler heat duty and flow rate of solvent that used in whole acrylic acid plant for optimization. Therefore, it is able to produce more amount of acrylic acid with desired quality in order to fulfill the demand in the market. Apart from that, it can provide a lot of insight before actual plant commissioning is done.

1.2 Problem Statement

Nowadays, the amount of acrylic acid production is become more from year to year due to its variety applications in order to fulfill human basic needs. Hence, due to this reason, the production of acrylic acid in acrylic plant must be increased also in order to meet the required demand. When the amount or capacity of production is increase in the acrylic plant, all the operating conditions of reactor and separation sections must be adjusted to another new optimum condition in order to maintain the desired purity products. Therefore, the acrylic acid plant has to precede optimization in order to overcome a large amount of acrylic acid production.

Moreover, vapor recovery system and liquid recovery system play an important role in recover or recycle back of the reactants and products such as propylene, acrylic acid, and acetic acid in order to prevent them being released into the environment, save raw material cost and increase more revenue. According to the Acrylic Acid MSDS (2005) and Acetic Acid MSDS (2005), acrylic acid and acetic acid are potentially hazardous material which will bring effect on living things' respiratory system, eyes, skin, or ingestion. Apart from that, loss of materials can cause the economic loss of that company and accidents incident may occurs because propylene is a flammable gas. Hence, optimization on this two recovery system can prevent the loss of hazardous materials to the environment, economic loss and improve safety in the acrylic acid plant.

1.3 Research Objectives

The objectives of this study are:

I. To simulate a production of acrylic acid process.

II. To optimize the operating conditions in reactor and separation sections of acrylic acid plant.

1.4 Research Questions

The research questions of this study are:

I. How to simulate a production of acrylic acid process?

II. How to optimize of operating conditions in reactor and separation sections of acrylic plant?

1.5 Scope of Study

The main objectives of this research are to optimize the reactor and separation sections in the production of acrylic acid process. In order to obtain the result, we have limited our research within a scope which consists of:

I. Simulation of acrylic acid plant by using Aspen Plus software.

II. Optimization parameter for plug flow reactor is only temperature.

III. Optimization parameters of the separation section are reflux ratio, feed tray location, pressure, temperature, molar flow rate of solvent and re-boiler duty only.

1.6 Expected Outcome

From this study, it is expected that by running the models and simulations on Aspen Plus software, each operating conditions and selection will be more understandable so that the optimized condition can be achieved for an acrylic acid plant. Besides that, all units such as plug flow reactor, flash drum, absorption unit, liquid-liquid extractor, two units of distillation columns in acrylic acid plant are expected to be optimized at the optimum conditions. Furthermore, an environmental friendly acrylic acid plant is expected to be achieved by reducing loss of hazardous materials to environment.

1.7 Significance of Study

The first significance is in the terms of publication. If this study were to be published, the findings can be read or researched again by others in order to simulate and optimize the acrylic plant again. The acetic acid, propylene and acrylic acid are hazardous materials which can harm all living things. However, this study is able to minimize the loss of hazardous materials to the environment so that the acrylic acid plant can become more environments friendly and have a higher safety aspect. Apart from that, this study is carried out so as to get a better design of acrylic acid plant with all separation units under optimum conditions. Furthermore, by conducting this study, a higher quality of desired products which include acrylic acid and acetic acid by optimizing the separation units in acrylic acid plant can be obtained. Lastly, this study is also able to maximize the profits, reduced energy consumption, higher processing rates, reduced maintenance cost, and longer time between shutdowns.

CHAPTER 2

LITERATURE REVIEW

2.1 Products of Acrylic Acid Plant

2.1.1 Acrylic Acid

The main product of the acrylic plant is acrylic acid which is a clear, colorless liquid at ambient temperature and pressure (Cascieri and Clary, 1993). It can be described as a pungent, rancid, irritating, acrid and sweet (Verschueren, 1996). One of the applications of acrylic acid is used as a starting material in the production of acrylic esters and as a monomer for polyacrylic and polymethacrylic acid and salts (Genium, 1999). Besides that, it is also used as a co-monomer for polymers used as flocculants and for polymers used in molding powder, construction units, decorative emblems and insignias (Genium, 1999). Moreover, acrylic acid is used in the manufacturing of plastics, in polymer solutions for coatings, in paint formulations for leather finishing, in paper coatings, in polishes and adhesives and in general finishes and binders (Genium, 1999). According to the Acrylic Acid MSDS (2005), acrylic acid is very hazardous when in contact with skin (permeator), corrosive to skin and eye contact, skin contact may produce burn, and irritation of respiratory tract.

2.1.2 Acetic Acid

Another product of acrylic plant is acetic acid. It is by-product which produced during oxidation of propylene process. Acetic acid is an organic compound with the chemical formula CH_3COOH. It is a colorless liquid and has a distinctive sour taste and pungent smell. It is used in manufacturing of drugs, dyes, plastics, food additives and insecticides (Malvda, 2007). Acetic acid is one of the simplest and most widely used carboxylic acids having many chemical and industrial applications. Total worldwide production of acetic acid is about 6.5 million tons per year; out of which about 5 million tones are produced by methanol carbonylation process and by bacterial fermentation and the remaining 1.5 million tons by recycling (Production Report, 2005). According to the Acetic Acid MSDS (2005), it is very hazardous in case of skin contact (irritant), of eye contact (irritant), and of inhalation. Besides that, it is classified as a weak acid, but concentrated acetic acid is corrosive and attacks the skin.

2.1.3 Physical and Chemical Properties

The physical and chemical properties of acrylic acid and acetic acid are summarized in Table 2.1.